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Residual stress determination in oxidized bulk metallic glass using X-ray diffraction and FIB/DIC methods

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The presence of residual stresses inside the engineering components generated by local inelastic deformation can influence material’s performance considerably during mechanical loading. Surface engineering of ZrCuAl-based bulk metallic glasses (BMGs) by low-temperature (<T\(_g\)) gaseous oxidizing is hypothesized to be possible in order to build-up compressive residual stresses in the surface region, which then results in decelerating the shear band propagation during deformation. In the current study stresses introduced as a consequence of ZrO\(_2\) (Al\(_2\)O\(_3\)) formation on thermochemically oxidized (Zr\(_{55}\)Cu\(_{30}\)Al\(_{10}\)Ni\(_5\))\(_{98}\)Er\(_2\) BMG were investigated. For this purpose, conventional X-ray diffraction \(\sin^2\psi\) and incremental core-ring focused ion beam (FIB) milling methods have been utilized. The BMG was initially oxidized in the controlled gaseous atmospheres imposing an extremely high pO\(_2\) at 600 K for 60 hr. The residual stress \(\sin^2\psi\) analysis was conducted on (011) reflection of the tetragonal-ZrO\(_2\) peak where it reveals the existence of compressive stress in ZrO\(_2\). Surface strain relief monitored in high-resolution SEM imaging of a deposited stochastic pattern during gradual milling and measured by digital image correlation (DIC) also indicated the occurrence of compressive residual stresses in the surface region of the oxidized BMG.